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STATUS AND DYNAMIC CHANGE OF REGIONAL MAN-LAND SYSTEM IN VIEW OF MICRO-LEVEL QUANTITATIVE ASPECT —Case Study of Gongyi City of Henan Province

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ABSTRACT: A micro-level analysis on man-land system is important in understanding the content of human geography in rural areas, particularly in the different regions. This paper is based on a survey undertaken in the three villages of Wugou Village, Hutuo Village, and Xiaonan Village of Gongyi City, Henan Province in April 2003. The survey covers three types of economic and social activities from 214 households. Data collected include 120 attributes for each household. By using theories from the relevant disciplines such as geography, mathematics, physics, ecology, and system sciences, this paper develops a framework employing the concept of system entropy in the status function of the man-land system. In this framework, the entropy change is used to show the evolution of the system, and the entropy flow to express the flow among the spatial parts of the system. Following the framework, and using a large set of household data from surveys, the paper makes a quantitative analysis of the village-level man-land system from a micro-perspective. After a theoretical investigation, the corresponding strategies in the paper are then put forward in order to adjust the unbalanced trend of the village man-land system from both perspectives of small-area and individual actors.

KEY WORDS: man-land system; village-level region; system entropy

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1 INTRODUCTION

The quantitative study of regional man-earth relationship system can be traced back to a long time ago. Paul Vidal de la Blache, a human geographer from France, put forward the idea of man-earth relativity, which was further developed by his student named Jean Brunhen (BRUNHEN, 1935). In the early 1980s, WU Chuan-jun, an academician from Chinese Academy of Sciences, expanded the view of the man-earth areal system (WU, 1981), and he believed that only these qualitative studies were hardly enough to analyze this system (WU, 1991). However, the synthetic achievements with quantitative methods were little. At present, most of these studies emphasized the following aspects: 1) theoretic studies on the man-earth relationship system (LU, 2002; MAO, 1995); 2) quantitative studies on this system from a macro perspective (ARROW, 1995; COHEN, 1995; MAO and YU, 2001a; 2001b); 3) quantitative studies on some factors of this system (FAN and LU, 2002; ZHU, 1997). But the comprehensive quantitative research is still insufficient.

WANG (1999) and CHAHARBAGHI and WILLIS (1999) listed some successful cases, but most of these achievements could not be put to use in practice because these studies usually lacked the concrete feasibility. These studies on regional man-land system from the microscopic approach can make up for these problems above in a certain extent. And it is a good idea to disclose the inherent laws of socio-economic phenomenon from the microscopic angle, such as the study on national regional disparity from the county-level perspective (LI and QIAO, 2001), the site-specific study on regional sustainable development (LI et al., 2001), the study on

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micro-scale sustainable development based on the concept of village ecology (HARALDSSON, 1998) and so on.

This paper attempts to deal with the following issues: 1) to explore the quantitative method of regional man-land system, which uses system entropy to present the system status, uses the entropy change to show the evolution of the system, and uses the entropy flow to express the flow among the spatial units of the system; 2) to construct the optimization measures of the system from a micro perspective.

2 METHOD

2.1 Dissipation Structure of Man-land System

According to the conditions of dissipation structure (NICOLIS and PRIGOGINE, 1997), the man-land system has some features as follows. Firstly, it is an open system. It can not only absorb the solar radiation, universe matter and the matter and energy beyond the region, but also receive the matter and energy within the man-land system, while massive matter and energy is also sent to the outside. Secondly, it is far away from the equilibrium status. On the side of human, the life system is far away from the equilibrium status because of individual metabolism. On the other side of earth, the process of metabolism and recirculation also exists. Actually, the balance of status itself means the end of life and the collapse of the system. Thirdly, the relationships among inner factors are non-linear. Man affects earth, which does not mean a simple relationship of reforming and controlling. Fourthly, there is material and energy dissipation within the system and between the inside and outside. In order to keep the order status of man-land system, the matter and energy with low value of entropy must be consumed, and the inner waste and high energy must be discharged to the surroundings. If not, the system may be disintegrated (MA and GUAN, 2002). Fifthly, the system has an order status in the macroscopic scale.

2.2 System Entropy

In the man-land system structure, we choose the disordered extent, but not the intensity of human activities to describe its negative effect on the surroundings and take it as a uniform standard to evaluate the effect of human activities in different areas. Regional carrying capacity mainly denotes the carrying capacity at a certain time including the nature carrying capacity as the foundation and the human carrying capacity that plays an important role in the man-land system. Given that the regional carrying capacity (C) is unaltered in the man-land system, the more disordered the human activities (M) are, the more possibly sudden change will happen, and then the bigger the system entropy (V) will be. And given that the regional human activities are changeless, the smaller the regional carrying capacity is, the stronger the possibility of sudden change will be and the bigger the value of system entropy (V) will be. So the following formula is achieved according to the above:

$$V=k\mathrm{Ln}\frac{M}{C}=k\mathrm{Ln}M-k\mathrm{Ln}C \qquad (1)$$

where, k is the harmony coefficient of the man-earth relationship. V_M shows the entropy value caused by human activities and V_C shows the entropy value caused by the earth environment in the system. With the unitary method, we can usually regard V_M as the source of positive entropy and V_C as the source of negative entropy in order to simplify and analyze problems, and so:

$$V_M=k\mathrm{Ln}M,\ V_C=k\mathrm{Ln}C\ \ \therefore V=V_M-V_C \qquad (2)$$

2.3 Entropy Change

This paper chooses the value of entropy change, which is the difference during a certain period, to show the development of man-earth system at a certain period. So,

$$\Delta V=V_2-V_1$$

where, ΔV is the entropy change between the two moments. V_1 is the entropy value in the first moment, and V_2 is the one in the second moment.

According to enlightenment of some scholars (FANG, 2000) and the relationship of these two kinds of entropy change, entropy change can be divided into the following nine types (Table 1).

In Table 1, ΔV shows entropy change; ΔV_M shows the entropy change caused by human activities; ΔV_C shows the entropy change caused by the earth environments; A', B', C', …, I' show the types of entropy change. The stability of A', (B', D'), E', (C', G'), (H', F'), I' is up in turn (without order distinction in brackets).

2.4 Status and Change of Man-land System

The man-land system in a village or village-level area may change along with the change frequency and the types of influence of the inner factors and the surroundings. If the effect of the inner leading factor or the effect of the environment exceeds the threshold, the system may change greatly and be reorganized as to be in another status characterized by different energy or nutrition circulation and different components and system functions.

The evolving course of man-land system in a village is a spiral rising motion that can be subdivided into four

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Table 1 Type of entropy change in man-land system

Man-land system		Human activity		
		$\Delta V_M > 0$	$\Delta V_M = 0$	$\Delta V_M < 0$
Regional carrying capacity	$\Delta V_C > 0$	A'	B'	C'
	$\Delta V_C = 0$	D'	E'	F'
	$\Delta V_C < 0$	G'	H'	I'

stages as the following. In the first stage, the human race is only a part of the nature, while the earth is absolutely in the dominant position in the man-earth system. The power of the human race is relatively weak, so this kind of village-level man-land system, which usually exists in the isolated mountainous area, is in the unharmonious status. In the second stage, the subjective initiative of the human race has been developing, such as the activities of agriculture, and the intensity of human activities is basically under the regional carrying capacity. Correspondingly, with the development of the human race, there is a relatively harmonious relationship between man and earth. In the third stage, with the appearance and development of industry, both the intensity of human activities and the extent of disordered human activities are increasing. Human race is completely in the dominant position. Because of the misuse of resources and even overuse, the man-land system of partial village or even the whole village is in the unharmonious status. In the fourth stage, with the further development of science and technology and the enlargement of the influence of the surroundings, the rural households' capacity of remaking the nature is rising gradually. The frequency of feedback from the nature is rising and speeding up at the same time. The human race draws lessons and then conforms to the law of the nature, which makes the relationship between man and earth friendly and harmonious further.

3 CASE STUDY

3.1 Study Area

Natural village is the least and most perfect unit in the aspect of study the village-level man-earth relationship (QIAO, 2005a). Because Gongyi City possesses these features including the relatively high-level economic development, worse environment and remarkable contradiction between man and land, we choose it as the study area to analyze the intrinsic mechanism and the evolving process of the man-land system. Then, it makes a show of the status development of this system according to the survey of typical villages in different development stages. In accordance with certain criteria (QIAO and DING, 2004), we take samples from about 2000 neighborhoods, 291 natural villages, and 18 towns in Gongyi City. With the methods of multi-stage sampling, probability non-distribution sampling and integral sampling (JIN et al., 2002), we select three neighborhoods of Wugou Village, one neighborhood of Hutuo Village and one neighborhood of Xiaonan Village, 214 rural households in all, as investigation objects.

Gongyi City, in the northwest of Henan Province, is located between 34 °31'- 34 °52' N and 112 °49'- 113 °17' E, and covers an area of 1052km^2. It has a continental monsoon climate in the warm temperate latitudes. Plenty of light and heat resources can support the growth of crops, which have biannual harvests. The average rainfall is 583mm, most of which centralizes in July, August and September. So the rainfall and the heat are in synchronism, which are suitable for the growth of crops. Since the late 20th century, Gongyi City has been awarded the title of National Hundred Strong Counties for three years, and put the 55th place as one of the National Hundred Counties with Strong Basic Economic Competitiveness in 2002. It is also one of the three strongest cities in the middle and west of China. In 2001, it had a local population of 793 000, and a non-local population of more than 110 000. The density of population was up to 866/km^2, and the farmland per capita was 0.043ha, of which non-irrigated farmland took up a high proportion of 77.2%. As for those areas studied in this paper, Xiaonan Village is located in the suburbs, Hutuo Village in a relative flat region, and Wugou Village in the southern mountainous region. There is a great divergence in the social and economic conditions among these three villages. In Wugou Village, the population growth shows a change tending to negative (about - 5.57‰ per year), which corresponds with the outward movement of local resident to a certain extent. The population of Hutuo Village has increased by 3.38‰ in recent decade. But that of Xiaonan Village has jumped by 8.42‰. Between 1990 and 2000, the total area of farmland in Wugou Village had added by 1.04ha, which was mainly caused by the reclamation of wastelands; that in Hutuo Village had reduced by 8.44ha, which was mainly caused by the enlargement of peasant courtyard; that in Xiaonan Village had decreased by 36.07ha, which mainly resulted from urbanization.

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3.2 Evaluation of Disorder Extent of Household Activities

According to the fact of the development in these villages studied, the village human activities can be subdivided into the following types: household's reproduction and living activity, agricultural activity, industrial activity and other activities.

3.2.1 Index system

We chose 12 indicators (No.1- No.12) to reflect household's reproduction and living activities (Table 2), 13 indicators (No.13- No.25) to present agricultural activities, 14 indicators (No.26- No.39) to show industrial activities, and 12 indicators (No.40- No.51) to express other households activities.

3.2.2 Data collection and analysis

According to the results of the survey on rural households and officers in charge of committees of the villagers and a portion of observation data from related departments of Gongyi City, we build a raw matrix about the index system of the disorder extent of human activities in these villages studied in this paper (QIAO, 2005b). The first step in data processing is to standardize the raw data matrix that has been sifted out the true from the false and been encoded. At the same time, we can translate its coordinates to remove the effect of the negative. In this process, we should normalize the indicators in order to keep them taking effect in the same direction.

Table 2 Value of weight on indicators of human activities

No.	Indicator	Value	No.	Indicator	Value
	Household's Reproduction and Living Activities			Industrial Activities	
1	Population	0.019	26	Exhaust gas from handicraft industry	0.018
2	Population growth rate	0.013	27	Solid waste from handicraft industry	0.020
3	Population engaged in economic activity	0.018	28	Exhaust gas from transport service	0.024
4	Domestic tribulation coefficient	0.016	29	Wastewater from transport service	0.024
5	Annual solid garbage per household	0.013	30	Solid waste from transport service	0.020
6	Non-degradable garbage	0.024	31	Exhaust gas of mining industry	0.022
7	Income from garbage-selling	0.014	32	Wastewater from mining industry	0.025
8	Household electricity consumption	0.016	33	Solid waste from mining industry	0.029
9	Water consumption for living	0.017	34	Exhaust gas from processing industry	0.029
10	Average level of education	0.016	35	Wastewater from processing industry	0.029
11	Physical quality	0.015	36	Solid waste from processing industry	0.025
12	Business consciousness	0.016	37	Exhaust gas from building industry	0.023
			38	Wastewater from building industry	0.022
	Agricultural Activities		39	Solid waste from building industry	0.021
13	Pesticide	0.021		Other Household Activities	
14	Chemical fertilizer	0.019	40	Population engaged in business activity	0.021
15	Organic fertilizer	0.019	41	Average amount of clients in shop per day	0.021
16	Time of agricultural management	0.017	42	Density of shops	0.023
17	Input-output rate of returning straw to field	0.014	43	Amount of restaurants	0.023
18	Labor power put in sowing	0.014	44	Average scale of restaurants	0.024
19	Time for sowing	0.015	45	Clients of restaurants	0.024
20	Agricultural facilities for sowing	0.017	46	Amount of clinics	0.018
21	Grain output	0.015	47	Average scale of clinics	0.021
22	Time for harvesting	0.016	48	Patients of clinics	0.021
23	Labor power put in harvesting	0.017	49	Labor power engaged in cleaning	0.024
24	Consumed energy for harvesting	0.015	50	Number of teachers	0.022
25	Leisure season	0.014	51	Number of students	0.018

Note: The information comes from the survey on related rural households and departments

3.2.3 Weight of indicators

According to the existing related achievements, we assign weightiness to the indexes with the method of improved entropy (QIAO, 2005b). The results are listed in (Table 2).

3.2.4 Model of disorder extent of human activities

According to the standardized data, which comes from the translation of the raw matrix about the index system of the disorder extent of human activities, and the weight of corresponding indicators determined with the method of improved entropy, we construct a model of the disorder extent of human activities as the following: the disorder extent of the village l in the year of k is assumed as M_{kl}.

$$M_{kl}=\sum_{j=1}^{51}\alpha_j p_{k(l)j} \quad (k=1,2;\ l=1,2,3) \qquad (3)$$

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where, j is the serial number of the index, α_j is the of the weight corresponding index, and p is the standardized value of the corresponding index.

3.2.5 Evaluation of disorder extent of human activities

The evaluation includes two aspects: 1) The monthly diversity of household activities. The household activities of Wugou Village mostly focus on June, October and December. June and October are the harvesting and sowing time; December is leisure season and most households are engaged in the stone mining industry (44.4%) and the stone processing industry (23.1%). The household activities of Hutuo Village mostly focus on June, July, September and October, which are mainly caused by the seasonal change in the agriculture. But the rural household activities of Xiaonan Village is remarkably different from that of the villages above, that is to say, the intensity of household activities is weak in the traditional busy seasons, which nearly corresponds with the industry structure. For the superiority in the geographic region, the rural household is actively engaged in the business and the service industry during the period around the Spring Festival. The month-level diversity of household activities of Hutuo Village is the biggest, Wugou Village the second and Xiaonan Village the smallest. On the whole, the extent of diversity in February is the largest, while that in June is the weakest. 2) The annual diversity of household activities. The average value of the disorder extent of household activities in 2002 exceeded that of 1990 by 25%, and the increase of Xiaonan Village was the biggest (up to 40%), Wugou Village the second (by 26%) and Hutuo Village the smallest (about 4%). From 1990 to 2002, the change of Xiaonan Village was up to 0.874, while that of Hutuo Village was only 0.064. In other words, the former is 13.7 times bigger than the latter. Additionally, both the absolute and the relative value of the diversity of the disorder extent of household activities in 2002 exceeded that of 1990 clearly.

3.3 Village Carrying Capacity

3.3.1 Index system

According to the related analysis and the fact of these villages studied, we design the index system of village carrying capacity as shown in Fig. 1.

3.3.2 Assign weight to indexes

In order to remove the effect of the negative number, extremum and the other related factors, we should translate the raw matrix of village carrying capacity with the following methods: standardized processing, normalization and entropy transform, etc. The processed data set (36 ×6

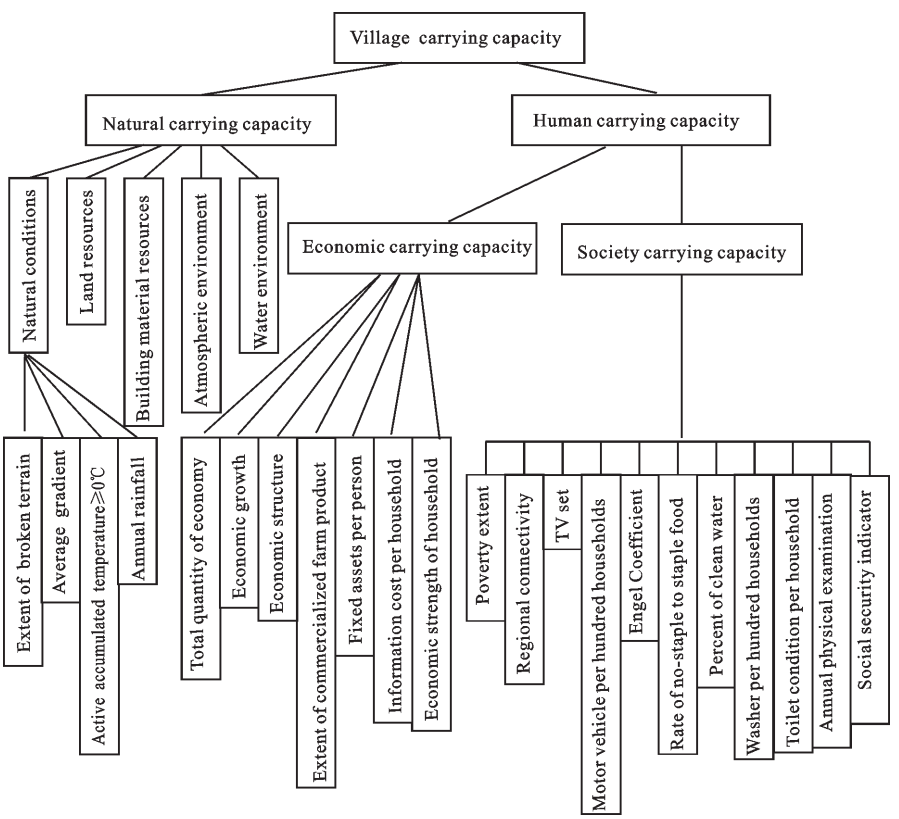

Fig. 1 Index system of village-level carrying capacity

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matrix) is the data foundation of the evaluation of village-level carrying capacity. According to the related steps of processing with the improved entropy, we make operation on the index system and then get the value of indicators (Table 3).

3.3.3 Model and result of evaluation

The evaluating model of village-level carrying capacity is similar to that of the disorder extent of village household activities, though they are different in the index system and the connotation of the model. We assume that

Table 3 Value of indictor of village-level carrying capacity

Indictor	Value	Indictor	Value	Indictor	Value
Extent of relief	0.028	Content of COD	0.025	Percent of clean water	0.023
Average gradient	0.026	Dissolved Oxygen	0.028	Washer per hundred households	0.025
Active accumulated temperature≥0℃	0.024	NH_4^+-N	0.033	Toilet condition of rural household	0.027
Annual precipitation	0.020	Organic matter including petroleum	0.028	Annual physical examination	0.033
Forest resources	0.030	Domestic sewage	0.033	Social security indicator	0.025
Grassland resources	0.028	Poverty degree	0.028	Total quantity of economy	0.040
Farmland resources	0.023	Regional connectivity	0.035	Economic growth rate	0.022
Wood resources	0.025	Housing condition	0.023	Economic structure	0.022
Stone resources	0.023	TV set	0.026	Extent of commercialized farm product	0.033
Concentration of suspended particles	0.036	Motor vehicle per hundred households	0.036	Quality and future growth of economy	0.034
N_xO	0.021	Engel Coefficient	0.019	Information cost per household	0.032
Concentration of SO_2	0.025	Rate of no-staple to staple food	0.025	Economic strength of household	0.033

the carrying capacity of the village t is M_{st} in the year of s.

$$M_{st}=\sum_{j=1}^{36}\alpha_j P_{s(t)j} \quad (s=1, 2; t=1, 2, 3) \qquad (4)$$

where, j is the serial number of the index.

According to the data calculated, the conclusions are drawn as follows. 1) The village carrying capacities of Wugou, Hutuo and Xiaonan villages increase in turn. The value was 1.6141, 1.8679, 2.3087 in 1990 and 1.6548, 2.1764, 2.8461 in 2002, respectively. 2) The absolute increase value of village carrying capacity also increases in turn. The carrying capacity of Wugou Village has increased by 0.0408 in the 12 years, Hutuo by 0.3085 and Xiaonan by 0.5374. The village change through the 12 years of Xiaonan Village is the biggest and Wugou the smallest, and the former is 13.18 times as much as the latter. 3) The relative value of the increase shows the similar trend. The annual growth rate is 0.21%, 1.28%, and 1.76%, respectively. 4) The extent of village diversity is rising. The absolute value (expressed in the form of standard deviation) was 0.2870 in 1990 and had increased to 0.4876 in 2002. The relative value was also increasing in the three villages studied. The variation coefficient was 0.1487 in 1990, which increased to 0.2191 in 2002.

3.4 Analysis of Entropy Change

The value of system entropy in Wugou, Hutuo, Xiaonan villages was up in turn in 1990, which was - 0.226, - 0.143, - 0.054 respectively. The average value was - 0.141 and it reduced by 52.56% in 2002. There were evident differences among these villages. From 1990 to 2002, the value of entropy change in the man-land system of the three villages was 0.209, - 0.114, and 0.127 in turn. One was negative but the other two were positive. From this angle, the extent of stabilization or harmony of the system in Wugou, Xiaonan and Hutuo villages increases in turn. Among these villages, the absolute value of the difference between 2002 and 1990 was evidently enlarging while the relative difference dropped to a certain extent, which showed a great change of the relationship between human activities and regional carrying capacity in these areas studied.

In terms of the swing of entropy change in the three villages studied, Wugou Village is the first, Xiaonan the second, and Hutuo the third. And the first two have a positive change, the last negative.

3.5 Status of Village Man-land System

3.5.1 Harmony extent as a whole

The average value of system entropy in the village man-land system was $\bar{V}$ = - 0.066 on the whole in 2002, indicating that the disorder extent of human activities did not surpass the village carrying capacity in these villages studied. Whether this trade-off is reasonable or not is worth studying deeply. We take the idea that evaluating the effect of the trade-off is determined by people's concept of value and their understanding of the environment feedback mechanism. With the passing of time and the changing of thought, the value concept changes, too. On the whole, as the influence of exterior human carrying capacity is relatively significant, the increased amount of human carrying capacity is more than the loss of natural carrying capacity. In terms of the three

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status variables in the man-land system, the average value of disorder extent of human activities was $\bar{V}_M$=2.1241 in 2002, which was smaller than the village carrying capacity, $\bar{V}_C$=2.2257, which reproves that this system is relatively harmonious to a certain extent and can basically bear the stress from human activities.

3.5.2 Harmony difference among villages

According to the analysis of influence of various factors within and without the system, the absolute difference is up to 0.139, which is bigger evidently than that of 1990. In Wugou Village, both the disorder extent of human activities and the regional carrying capacity are relatively small, and in a sense, as a light "particle", this village has a large swing caused by the surroundings. In Hutuo Village, there is a great fund flowing into the man-earth relationship system caused by the outward working of most villagers, which also lightens the stress of the carrying capacity. In Xiaonan Village, the strained relationship between man and earth is mainly caused by the Gongyi Alkali Plant, which causes serious environmental pollution.

The above analysis is based on the fact of the villages studied on the whole and is the foundation to decide whether the man-land system is harmonious or not. There is a remarkable difference in the harmony extent of man-land system in the three villages, and the value of system entropy is - 0.017 in Wugou Village, - 0.256 in Hutuo, and 0.073 in Xiaonan. So we can draw the following conclusions: 1) the man-land system of Hutuo Village is relatively harmonious; 2) the man-land system of Wugou Village is still a relatively harmonious one; 3) the man-land system of Xiaonan Village is a comparatively maladjustment one.

3.5.3 Elasticity difference among villages

According to relative literatures (VOGT et al., 1997; HOLLING, 1973) and the investigation and analysis of these villages, we come to the following conclusions. 1) The man-land system of Hutuo Village possesses the strongest flexibility, Xiaonan Village the second and Wugou Village the last. Wugou Village is located in the mountainous area with less precipitation and fragile ecosystem, which leads to a strong rigidity of village man-land system. In Xiaonan Village, there is serious pollution caused by the chemical industry with a low technical level, which causes a relatively flimsy man-land system. The man-land system of Hutuo Village possesses the strongest flexibility, compared with those of the other villages. 2) In terms of the index of variety in the man-land system, the biggest is in Xiaonan Village, with a value of 978.90, the next is in Hutuo Village, with a value of 835.67, and the last is in Wugou Village, with a value of 584.88. This indicates that, in terms of the variety of the components and the status of village man-land system, Xiaonan Village is the first, and on condition that there is not serious pollution, it also possesses a relatively strong flexibility.

3.6 Dynamic Change of Village-level Man-land System

The features of the dynamic change at a certain time in the village-level man-land system include the change direction (towards the direction of sustainable development or not) and the change extent (slowness or jump).

In these villages studied, the value of system entropy has been increased from - 0.1408 in 1990 to - 0.0668 in 2002, which indicates that the system moves towards the unsustainable on the whole. According to the environment observation, the village environment degrades to a certain extent. In terms of the quality indicator of atmosphere, the average concentration of suspended particles was 0.123mg/Nm^3 below National Ⅱ-level Standard in 1990 and had increased to 0.21mg/Nm^3 above the National Ⅱ-level Standards in 2002. The concentration of compounds including nitrogen and oxygen has increased from 0.045mg/Nm^3 in 1990 to 0.161mg/Nm^3 in 2002, which exceeds the National Ⅱ-level Standard (0.04 mg/Nm^3) by four times, and the absolute increase is 3.58 times of that in 1990. As to the quality indicator of water, the content of COD has increased by 9.33mg/L, that of compounds including nitrogen and oxygen has increased by 0.70mg/L and that of organic matter has increased by 0.04mg/L. In terms of the two main factors in the man-land system, the value of the disorder extent of human activities was 1.6983 in 1990 and had increased to 2.1241 in 2002, which indicates that the disorder extent was rising on the whole in these villages studied. The value of the village carrying capacity was 1.9303 in 1990 and 2.2257 in 2002, which indicates that the carrying capacity is rising too. But it does not mean the improvement of environment on the whole. This phenomenon is caused by positive difference between the increased amount of village human capacity and the loss of village carrying capacity; that is to say, the effect of the two factors shows positive entropy on the whole.

The change extent of system entropy is larger. 1) The value of the system entropy has increased by 0.0740 from 1990 to 2002. 2) The extent of change in Wugou Village is the biggest in these years, the next is Xiaonan Village, and the last and the smallest is Hutuo Village. 3) The value of the disorder extent of human activities in 2002 has increased by 25 percent points compared to that in 1990 in these villages studied, which indicates

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that the intensity and the disorder extent of human activities increase. The value of the change in Xiaonan Village is the biggest (nearly 40 percent points), that of Wugou Village the second (28 percent points), and that of Hutuo Village the smallest (about 2 percent points). In terms of the village carrying capacity, the absolute increase is 0.2953 from 1999 to 2002. The human carrying capacity has increased from 0.9906 to 1.2474. The village carrying capacity increases with the progress of science and the development of society.

4 CONCLUSIONS AND DISCUSSION

With massive factors involved in the man-land system, it is a good idea to make a quantitative study from a micro perspective. Choosing Wugou, Hutuo and Xiaonan villages as study areas, we try to explore quantitative methods from a micro angle including micro region (village) and micro individuals (rural households, local enterprises, local authorities) in this paper. In the research, we find that this system has a dissipation structure. It is relatively reasonable and basically feasible to interpret and analyze the status, evolving course, spatial flowing and so on of the system with entropy theory. We also designed related coordinating measures from this view compared with the formerly macro-perspective.

According to the investigation of 214 rural households, we have achieved the data set of socio-economic conditions and peasant behaviors, input-output analysis of basic farmland, investment and consumption, the conditions of housing, the use and the change of farmlands, the distribution of labor-time in the month-level and space, environment observation, etc. in this paper. This data set has formed a 214×120 matrix, and its item reaches 25 000, which will overpass 30 000 if the data of environment observation and village investigation were added. The major work in this paper is to achieve huge data on micro scale, which will lay the foundation for the future research.

The man-earth system and its factors show different features in the process of change in these villages. The disorder influence of industry activities on the environment is the strongest among all the kinds of household behaviors. The disorder extent of household activities in Wugou, Hutuo and Xiaonan villages goes up in turn. In terms of the seasonal change, household activities focus on June, October, December in Wugou Village and on June, July, September, October in Hutuo Village. However, it is in the other way in Xiaonan Village, that is to say, the intensity of household activities is weak in the traditional busy seasons but strong around Chinese Spring Festival. This phenomenon is caused by the great difference of industry structure and local culture. The carrying capacity of these villages is also up in turn. In 2002, the average value of system entropy was negative, which indicated that the disorder extent of household activities did not overtop the carrying capacity. In terms of the degree of harmony between man and earth, the system in Hutuo Village is relatively harmony, that in Wugou Village the second and that in Xiaonan Village the worst or maladjusted. In a word, the development of the man-land system moves toward the direction of unsustainable development, which is confirmed by the environment observation.

The development in this direction can be slowed down or even reversed with the following measures from the micro perspective. First, develop the courtyard economy, planting trees in the country space, and enrich culture, etc. Second, make management strategies for farmland, such as optimizing planting structure, returning straw to field, and broadly using water-saving technology. Third, call for green production, control enterprise pollution strictly, strengthen cultural building, and foster innovation ability. Fourth, pay more attention to rural households' behaviors of consumption, investment, part-time employment, population floating and so on, propagandize environment policies, attract households' attention to participate in, and penetrate the thought of sustainable development into household's daily life. Fifth, bring local authority's office of guidance and service into play. On the whole, the core question focuses on the lack of water resources in Wugou Village, the denseness of small-farmer consciousness in Hutuo Village, and the deficiency of new technology and the irrational industry structure in Xiaonan Village.

The relationship between man and earth in the process of interaction is nonlinear, and how to describe this reasonably is still one of directions worthy of further study in the future.

REFERENCES

ARROW K, 1995. Economic growth, carrying capacity, and the environment [J]. Ecological Applications, 6(1): 13- 15.

BRUNHEN J (Translators: REN Mei-e, LI Xu-dan), 1935. Principle of Man and Earth [M]. Nanjing: Zhongshan Press. (in Chinese)

CHAHARBAGHI K, WILLIS R, 1999. Study and practice of sustainable development [J]. Engineering Management Journal, 9(1): 41- 48.

COHEN J E, 1995. Population growth and earth's human carrying capacity [J]. Science, 269: 341- 346.

FAN Jie, LU Xin, 2002. The study core of man-earth system: land use change [J]. Earth Science Frontiers, 9(4): 1- 2. (in

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Chinese)

FANG Chuang-lin, 2000. The dynamical foundation for the system of man and earth in the district development planning [J]. Earth Science Frontiers, 7(supplement): 5-10. (in Chinese)

HARALDSSON H V, 1998. Is ecological living in Sweden different from conventional living? [D]. Lund: Lund University master's thesis.

HOLLING C S, 1973. Resilience and stability of ecological systems [J]. Annual Review Ecological System, 4(1): 1-24.

JIN Yong-jin, JIANG Yan, LI Xu-ying, 2002. Sample Technology [M]. Beijing: China Renmin University Press. (in Chinese)

LI Xiao-jian, PETERSON J, LIU Gang-jun et al., 2001. Assessing regional sustainability: the case of land use and land cover change in the Middle Yiluo catchment of the Yellow River basin, China [J]. Applied Geography, 21: 87-106.

LI Xiao-jian, QIAO Jia-jun, 2001. County level economic disparities of China in the 1990s [J]. Acta Geographica Sinica, 56(2): 136-145. (in Chinese)

LU Da-dao, 2002. Theoretical studies of man-land as the core of geographical science [J]. Geographical Research, 21(2): 135-145. (in Chinese)

MA Jian-hua, GUAN Hua, 2002. System Science and Its Geographical Applications [M]. Beijing: Science Press. (in Chinese)

MAO Han-ying, 1995. Man-earth System and Regional Sustainable Development [M]. Beijing: China Science and Technology Press. (in Chinese)

MAO Han-ying, YU Dan-lin, 2001a. Regional carrying capacity in Bohai Rim [J]. Acta Geographica Sinica, 56(3): 363-371. (in Chinese)

MAO Han-ying, YU Dan-lin, 2001b. A study on the quantitative research of regional carrying capacity [J]. Advance in Earth Sciences, 16(4): 549-555. (in Chinese)

NICOLIS G, PRIGOGINE I, 1997. Self-organization in Nonequilibrium Systems for Dissipative Structure to Order though Fluctuations [M]. New York: Wiley-Interscience.

QIAO Jia-jun, 2005a. Quantitative research of regional man-land relationship [J]. Human Geography, 20(1): 81-85. (in Chinese)

QIAO Jia-jun, 2005b. Quantitative Research on Man-land Systems in the Representative Regions [M]. Beijing: Science Press. (in Chinese)

QIAO Jia-jun, DING Peng-fei, 2004. Comparative study of energy input and output in villages' farmland systems: the case of three types of villages in Gongyi County, Henan, China [J]. Resources Science, 26(5): 139-146. (in Chinese)

VOGT K, GORDON J, WARGO J, 1997. Ecosystems [M]. New York: Springer-Verlag.

WANG Wei-zhong, 1999. Local Sustainable Development [M]. Beijing: The Commercial Press. (in Chinese)

WU Chuan-jun, 1981. Special study fields and the coming tasks of geography [J]. Economic Geography, (1): 5-10, 21. (in Chinese)

WU Chuan-jun, 1991. The core of geographical study: man-earth areal system [J]. Economic Geography, 11(1): 1-6. (in Chinese)

ZHU H J, 1997. Sustainable Development and Land Utilization [M]. Hong Kong: China Hong Kong Yearbook Press.

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